Image Segmentation and Identification of Brain Tumor using FFT Techniques of MRI Image

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***Abstract*—The image processing tools are extensively used on the development of new algorithms and mathematical tools for the advanced processing of medical and biological images. Given an MRI scan, first segment the tumor region in the MRI brain image and study the pixel intensity values. A detailed procedure using Matlab script is written to extract tumor region in CT scan Brain Image and MRI Scan Brain Image. MRI Scan has higher resolution and easier identification compare to CT scan Brain image. Fast Fourier Transform is used here to study the tumor region of MRI Brain Image in terms of its pixel intensity. Types of FFT like Zero padded FFT, Windowed FFT are used to study the signal converted from the MRI Brain Image. It is found that lesser spectral leakage for Zero Padded Windowed FFT than other Types of FFT and hence the tumor cell identification is easier than other methods. Finally higher pixel intensity values of the cells gives identification of presence and activeness of tumor cells.**

***Index Terms*—Magnetic Resonance Imaging, Fast Fourier Transform, Zero padded Transform and Windowed Fourier Transform**

I. Introduction

Real world signals can be anything that is a collection of numbers, or measurements and the most commonly used signals include images, audio and medical and seismic data. In most digital signal processing applications, the frequency content of the signal is very important. The Fourier transform (FT) is the most popular transform used to obtain the frequency spectrum of a signal. Magnetic resonance imaging (MRI) is excellent for showing abnormalities of the brain such as: stroke, hemorrhage, tumor, multiple sclerosis or lesions[1].Medical image analysis typically involves heterogeneous data that has been sampled from different underlying anatomic and pathologic physical processes. In the case of glioblastoma multiforme brain tumor (GBM), for example, the heterogeneous processes in study are the tumor itself, comprising a necrotic (dead) part and an active part, the edema or swelling in the nearby brain, and the brain tissue itself. Not all GBM tumors have a clear boundary between necrotic and active parts, and some may not have any necrotic parts [2]. The biggest achievement of Fourier's work was the fact, that functions in the frequency domain contain exactly the same information as originals: this means, that people are able to perform analysis of a function from a different point of view. Fast and efficient way of calculating Discrete Fourier Transform, which reduces number of arithmetical computations from O (N^2) to O(N*$\log_2$N) is called as FFT algorithm. Key of the algorithm is data reorganization and further operations on it. The so called "Cooley-Tukey" algorithm is by far the most common FFT algorithm [3]. In order to perform good quantitative studies, ROI's within the brain must be well defined. In traditional methods, a skilled operator manually outlines the ROI's using a mouse or cursor. More recently, computer-assisted methods have been used for specific tasks such as extraction of MS lesions from MRI brain scans [4], [5]. High-grade gliomas represent rapidly growing malignant brain tumors. Early diagnostics of this decease and immediately applied treatment entails better life prognosis for the patient. Merinsky et al. [6] proposed a technique which involves image preprocessing, feature extraction, and classification of the extracted features using an artificial neural network. Henry L.BUIJS [7] proposes yet another type of parallel implementation consisting of carrying out more than one radix pass simultaneously for speeding up of implementation, regardless of the size of N where N=r^2 .The survey by Clarke et al. of segmentation methods for MR images [8] describes many useful image processing techniques and discusses the important question of validation. The various image processing techniques used for segmenting the brain can be divided into several groups: those required to perform a crude threshold-based extraction of the brain, followed by refinement of brain contours; statistical methods for brain segmentation, and region growing methods.

II. RELATED WORK

David S. Gilliam, Texas Tech University [11] has included the concept of removing effects of Gibb's phenomena in Fourier series approximation of discontinuous functions which generates a "window vector" used to do filtering. Harris, F.J. [12] makes a concise review of data windows and their affect on the detection of harmonic signals in the presence of broad-band noise, and in the presence of nearby strong harmonic interference and addresses to a number of common errors in the application of windows when used with the fast Fourier transform and also includes a comprehensive catalog of data windows along with their significant performance parameters from which the different windows can be compared. R. B. Dubey et.al [13] proposed a semi-automated region growing segmentation method to segment brain tumor from MR images. The proposed method can successfully segment a tumor provided that the parameters are set properly, to segment 8-tumor contained MRI slices from two brain tumor patients and satisfactory segmentation results are achieved.

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Heath et.al [14] suggested a region growing segmentation approach of taking the image of the tumorous brain there is a need to process it since the image does not give the information about the numerical parameters such as area and volume of the infected portion of the brain. Magnetic resonance imaging (MRI) of the prostate has been shown to provide improved resolution of intraprostatic structures and the prostate boundary compared to CT and ultrasound [15],[16]. Yutai Ma[17] developed an error propagation model and derived an accurate error expression and error variance for FF'T computations in fixed-point and block floating -point arithmetic respectively. This paper found out that some round off errors at different stages correlate with each other and the density of correlations is closely associated with the round-off approach used in butterfly calculations. Tzimiropoulos et.al [18] presented a gradient-based approach which operates in the frequency domain for the estimation of scalings, rotations, and translations in images. A key feature of Fourier-based registration methods is the speed offered by the use of FFT routines

III. PROPOSED SYSTEM

A. System Overview

Figure 1 shows the overall system flow diagram. Input is the MRI image and applying the Fast Fourier Transform to the input, zero-padded FFT, windowed FFT, windowed zero-padded FFT's are obtained. Here Zero Padded FFT, Windowed FFT and ordinary FFT is used to compute the spectral leakage of the MRI brain image to define accurately the boundary region of tumor and other cells in the brain and outputs are obtained for each stage and results are compared.

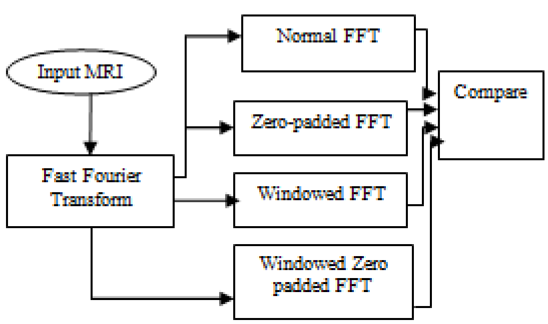

Figure1. System flow diagram

B. Fast Fourier Transform For Image Processing

Fast Fourier Transform on image processing is given in detail in [9] and its types are described in [10]. Fourier transform is used here to extract frequency components of a signal and only suitable for stationary signals. Fast Fourier Transform is used here to analyze non stationary signals such as image and have a good time and frequency localization. Here the signal is divided into small portions which are stationary. Georgios et.al [18] presented a gradient-based approach which operates in the frequency domain for the estimation of scaling, rotations, and translations in images. A key feature of Fourier-based registration methods is the speed offered by the use of FFT routines. The Fast Fourier transform is applied to these segments and mapping a signal in to two-dimensional function of time and frequency.Windowed FFT is defined as product of sinusoidal signal and windowed function (rectangular window). Zero padded is used to increase number of points (length) and for checking spectral leakage. The pixel cells having higher intensity and also changes in intensity value in the transition. Therefore while taking FFT of image signal which shows the changes in pixel intensity from the tumor region to other regions. The (forward one-dimensional) discrete Fourier transform of an array X of n complex numbers is the array Y is given by

$$Y[k] = \sum_{j=0}^{n-1} X[j]\,\omega_n^{jk}. \tag{1}$$

where $0 < k < n$ and $\omega_n = \exp(-2\pi\sqrt{-1}/n)$. Implemented directly, Eq. (1) would require $\theta(n^2)$ operations; But Fast Fourier transforms are $O(n \log n)$ algorithms to compute the same result.

IV. Magnetic Resonance Imaging

MRI is used to produce images of soft tissue of human body. It is used to analyze the human organs without the need for surgery.MRI for brain images are analyzed here and image processing techniques are used to characterize the tumors in the brain. In MRI, they appear either as hypo-intense (darker than brain tissues) or as iso-intense (same intensity as brain tissue) in T1-weighted scans and as hyper-intense (brighter than brain tissues) in T2-weighted scans[21,22].

TABLE I.
PARAMETERS DIFFERENTIATING MRI AND CT SCAN

Properties	CT scan	MRI scan
Area	9356 pixels per unit area	10651 pixels per unit area
Intensity of pixels in tumor region	120 to 170 pixels per inch	150 to 220 pixels per inch

The advantage of MRI is its ability to image in any plane unlike CT.MRI can create upper to lower in axial plane, right to left in sagittal plane and front to back in Coronal cross sectional view of brain image.

V. Implementation and results

A. Algorithm for Enhancement and identification of tumor

MRI brain image and CT scan image are considered in this section to enhance for non uniform illumination, then using this image to identify the tumor region. This enhancement will be useful for characterizing the tumor region. Then by using the bar graph,the intensity of the pixels in the tumor region is calculated and plotted for both CT and MRI brain image. The following procedure is adopted for enhancement of image, tumor identification and to

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compute the statistical properties of image.

Algorithm steps:

1. Read the MRI and CT scan image. and estimate the background of both the images.
2. Subtract the background image from original image.
3. Increase the Image contrast and Threshold both images.
4. Label objects of the image and examine the matrix.
5. Measure the object properties of image and Compute statistical properties and create histogram of the area of the specified tumor region.

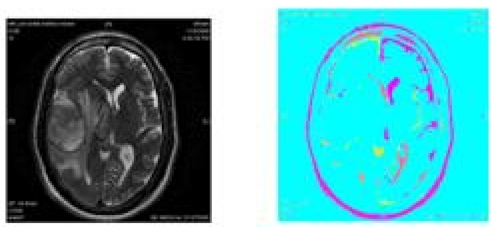

Figure 2. MRI brain with tumor and its background

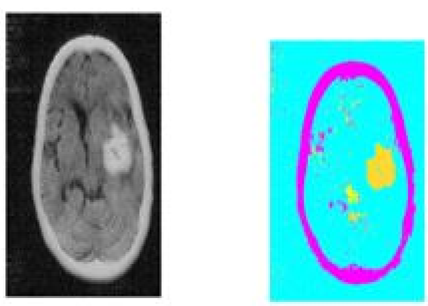

Figure 3. CT of brain with tumor and its background

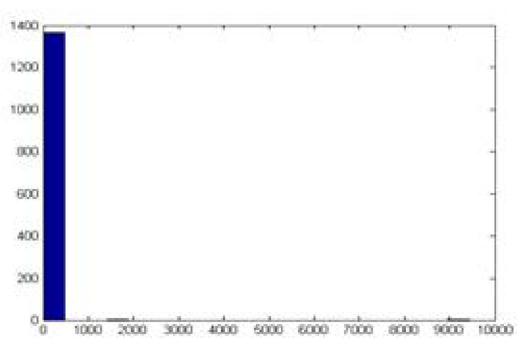

Figure 4. Bar chart of pixel intensity Vs number of pixels for MRI scan.

Fig. 2 shows the image of MRI and its background illumination Fig. 3 shows the image of CT and its background illumination. Background illumination is brighter in the center of the image then at the edges. Then by applying the thresholding function to both images the tumor region is extracted. The intensity of pixel in tumor region has higher value than other regions. MRI scans are having higher pixel intensity values of tumor region as compared to CT scan. Higher pixel intensity values of MRI scan shows well defined tumor region. Area of the tumor region is plotted in bar chart as shown in Fig 4 and 5. Table 1 show the parameters which are studied from Fig. 1 and Fig. 2. The results shows variation of intensity values from 170 to 220pixel/inch which conforms presence of tumor in the region. Next section deals with Fast Fourier transform is applied for MRI image to differentiate tumor cells with ordinary cells.

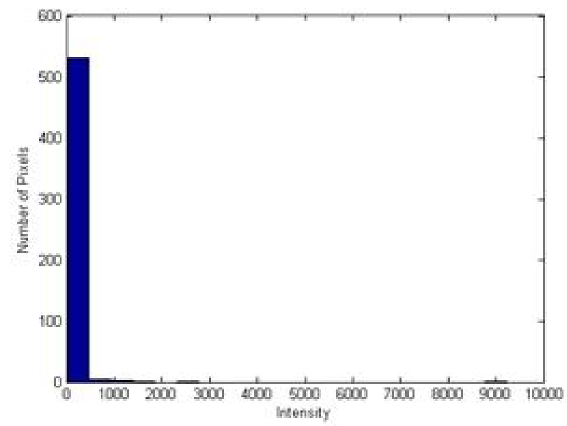

Figure 5. Bar chart of pixel intensity Vs number of pixels for CT scan.

VI. FFT IMPLEMENTATION

Matlab script used to show the difference between FFT of Brain Image with window and zero padding. Script calculates FFT and plot of Magnitude versus frequency for the given image, Normal FFT does not give correct amplitude and has spectral leakage. Windowed zero padded FFT gives both correct amplitude as well as minimal spectral leakage with higher amplitude. Figure 6 to 9 shows the plot of magnitude Versus frequency of MRI image of selected tumor region layers from its row pixel values(10,14,28 and 253). The MRI brain image consist of 512 layers of pixel with its intensity (Converted as amplitude in micro volts) is considered here and tumor region starts from 14^{th} to 253^{rd} rows of pixels in the MRI brain region. Each layer is converted in to simple sinusoidal wave with defined frequency up to 500 Hz and FFT is applied to find spectral leakage in the sense that the presence of tumor related cells in nearby brain regions. The following procedure is adapted in Matlab to study the tumor cells

1. Read Image of MRI brain scan and use morphological opening to estimate the background
2. Subtract the background from the original MRI brain Image, increase the image contrast and threshold the MRI Image
3. Label objects in the Image and examine the label matrix of MRI Image

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4. View the whole label matrix image
5. Measure object properties in the image and compute statistical properties of objects in the MRI Image

Fig. 6 shows the details about non tumor region in which higher leakage of brain cells around tumor region, also windowed zero padded FFT gives the lesser leakage of ordinary cells in the boundary around tumor cells.

Fig. 7 to 9 shows the tumor region cells and spectral leakage is less for normal brain cells and more for tumor cells. It can be proved from the figure 7 to 9 more leakages in the frequency region of 50 to 400 Hz with intensity value more than 250 which shows the non uniformity in the pixel values and proves to be tumor cell. Fig. 9 shows the plot of boundary layer of tumor cells with the ordinary brain cells, it is found that lesser pixel intensity of around 100 at the middle and hence lesser spectral leakage from windowed zero padded FFT. This proves that tumor cells differ from the ordinary brain cells.

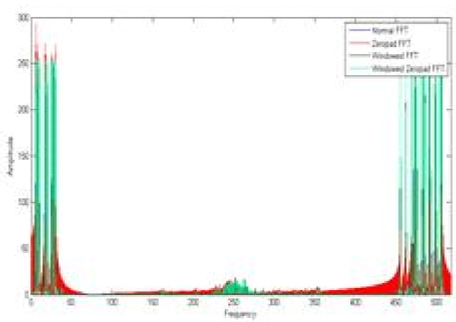

Figure 6. Amplitude Vs frequency of 10th pixel layer of tumor region in MRI Image

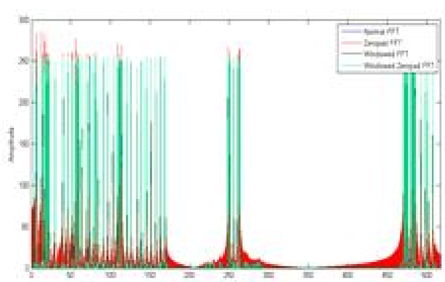

Figure 7. Amplitude Vs frequency of 14th pixel layer of tumor region in MRI brain Image

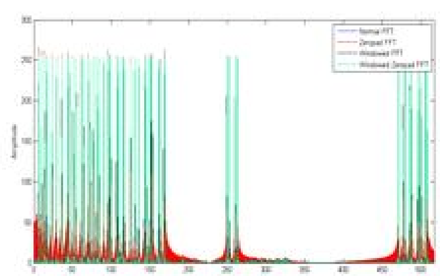

Figure 8. Amplitude Vs frequency of 28th pixel layer of tumor region in MRI brain Image

In all the diagrams from figure 6 to 9, green regions are calculated from windowed zero padded FFT and red regions are zero padded FFT. Zero padded gives lesser spectral leakage than ordinary FFT. Fig. 10 shows the bar chart pixel intensity values (amplitude of the signal) Vs each rows specified. It is found that higher intensity at the boundary of 253 and 14 respectively. These outputs are helpful in framing the boundary accurately between tumor and ordinary brain cells. The intensity value of more than 150 signifies the active region of tumor. Further pixel intensity values can be used to study the characteristics of tumor

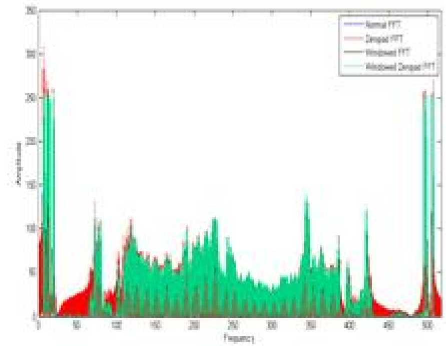

Figure 9. Amplitude versus frequency of 253rd ((last layer of tumor) pixel layer of tumor region in MRI brain Image

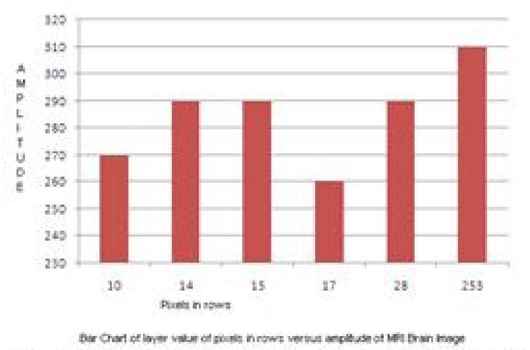

Figure 10. Bar chart of pixel rows in MRI image Vs amplitude (intensity of pixels)

VII. CONCLUSION

Image processing tools are used to extract tumor region of MRI image and CT scan brain images. Fast Fourier Transform is used to study the nature of tumor region and its identification. Boundary layers between the tumor cells and ordinary cells are differentiated using pixel intensity values. Types of FFT are used to study the spectral leakage of tumor cells with the ordinary cells. It is found that higher intensity values identifies tumor region and windowed zero padded FFT gives lower spectral region and classifies accurately. Further this study is useful for characterizing the tumor region.

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REFERENCES

[1] Victor Musoko, "Biomedical signal and image Processing," Ph.D. Thesis, Institute of Chemical Technology, Prague, Department of Computing and Control Engineering, Prague, July 2005.

[2] Jason J. Corso, , Eitan Sharon, Shishir Dube, Suzie ElSaden, Usha Sinha, and Alan Yuille, "Efficient Multilevel Brain Tumor Segmentation with Integrated Bayesian Model Classification," *IEEE Trans. Med. Imag*., vol. 27, no. 5, pp.629–640, May. 2008.

[3] Michal Dobroczynski, "2D FFT in Image Processing: measurements, implementation, parallelization and computer architecture," Final thesis**,** Department of Electrical Engineering and Information Technology, Engineering College of Copenhagen, Denmark, Spring 2006.

[4] B. Johnston, M. S. Atkins, B. Mackiewich, and M. Anderson, "Segmentation of multiple sclerosis lesions in intensity corrected multispectral MRI," *IEEE Trans. Med. Imag*., vol. 15. pp. 154–169, Apr. 1996.

[5] P. Zijdenbos, B. M. Dawant, R. A. Margolin, and A. C. Palmer, "Morphometric analysis of white matter lesions in MR images: Method and validation," *IEEE Trans. Med. Imag*., vol. 13, p. 4, pp. 716–724,Dec. 1994.

[6] Z. Merýnsky, E. Hostalkova, A. Prochazka, "Brain Tumour Diagnostic Support Based on Medical Image Segmentation," Institute of Chemical Technology, Department of Computing and Control Engineering, Prague.

[7] H. L. Buijs, **A.** Pomerleau, M. Fournier, "Implementation of a Fast Fourier Transform (FFT) for Image Processing Applications," *IEEE Transactions on Acoustics, Speech, And Signal Processing*, vol.ASSP-22,No.6 , pp.420-424,Dec 1974.

[8] L. P. Clarke, R. P. Velthuizen, M. A. Camacho, J. J. Heine, M.Vaidyanathan, L. O. Hall, R. W. Thatcher, and M. L. Silbiger, "MRI segmentation: Methods and applications," *Magn. Reson. Imag*., vol. 13,no. 3, pp. 343–368, 1995.

[9] http://software.intel.com/enus/articles/implementation-of-fast fourier-transform-for-image-processing-in-directx-10/

[10] www.dsprelated.com/.../ Spectrum_Analysis_SinusoidWindowing.html.

[11] David S. Gilliam, "Discrete Fourier Transform," *Department of Mathematics*, Texas Tech University.

[12] F.J. Harris, "On the Use of Windows for Harmonic Analysis with the Discrete Fourier Transform," *IEEE Proc.*, vol 66, no 1, Jan 1978, pp 51

[13] R. B. Dubey, M. Hanmandlu, S. K. Gupta and S. K. upta, "Region growing for MRI brain tumor volume analysis," *Indian Journal of Science and Technology*, Vol.2 No. 9, pp.2-31, Sep 2009.

[14] Heath LM, Hall LO, Goldgof DB and Murtagh FR, "Automatic segmentation of non-enhancing brain tumors in magnetic resonance images," *Artificial Intelligence in Med*. 21, pp.43-63, 2001.

[15] Parker, C. C., Damyanovich, A., Haycocks, T., Haider, M., Bayley, A., and Catton, C. N., "Magnetic resonance imaging in the radiation treatment planning of localized prostate cancer using intra-prostatic fiducial markers for computed tomography co-registration," *Radiother Oncol.* 66, pp.217–224 ,Feb 2003.

[16] Rifkin, M. D., Zerhouni, E. A., Gatsonis, C. A., Quint, L. E., Paushter, D. M., Epstein, J. I., Hamper, U., Walsh, P. C., and McNeil, B. J., "Comparison of magnetic resonance imaging and ultrasonography in staging early prostate cancer results of a multi-institutional cooperative trial.," *N Engl J Med* ,323,pp. 621–626,Sep 1990.

[17] Yutai Ma, "An Accurate Error Analysis Model for Fast Fourier Transform," *IEEE Trans. Signal Processing* vol. 45**,** no. 6, pp.1641-145, June 1997.

[18] Georgios Tzimiropoulos, Vasileios Argyriou, Stefanos Zafeiriou and Tania Stathaki," Robust FFT-Based Scale-Invariant Image Registration with Image Gradients," *IEEE Transactions On Pattern Analysis And Machine Intelligence*, ,vol. 32, No. 10,pp.1899-1906, October 2010.

[19] Clark M.C., Hall L.O., Goldgof D.B., Velthuizen R., Murtagh F.R., and Silbiger M.S., "Automatic Tumor Segmentation using Knowledge-Based Technique, IEEE Transaction on Medical Imaging,vol. 17, no. 2, pp. 187-201, 1998.

[20] Thamburaj A.V., Neurology and Systemic Malignance, Apollo Hospital,chennai,India, http://www.thamburaj.com/ cns_systemic_malignancy.htm, 2009.

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